The Recyclotron Project at the 88-Inch Cyclotron

M.A. McMahan[†], L. Bernestein[‡], J. Cooper[†], N. Benczer-Koller[§], J. Becker[‡], Y. Dardennes[‡], A. Davis[††], G. Kumbartski[§], T. Mertzimekis[§], M. Murry,[**] J. Powell[†], A. Schiller[‡], M. Smith,[§], T.-Z. Wang[‡], and D. Wutte[†]

The Recyclotron Project is an effort to produce and accelerate radioactive ion beams (RIBs) of Kr and Br isotopes using the 88-Inch Cyclotron as both the production and post-accelerator. The project builds on both the experience and direct techniques developed for the BEARS project at the Cyclotron.

RIBs from BEARS are limited to very light species by the maximum energy of the Biomedical Isotope Facility and the need to use internal gas targets. By using the versatile 88-Inch Cyclotron as the production accelerator instead, the range of potential RIBs is extended to a large portion of the periodic table. The tradeoff is that one can only work with RIBs of half-life greater than a few hours. Even so, there is still a large number of potential candidates.

The Recyclotron Project is science driven, in that it was started at the request of users and the beams being pursued are those of greatest interest scientifically. The region is of interest to astrophysicists modelling the p-process for formation of elements in Type II Supernovae neutrino-driven winds. [1] A measurement of the ^{77}Br(p,γ) cross section should shed light on these models as it is one of the branch points for the reaction network. In nuclear structure, the N=Z nucleus ^{72}Kr is of particular interest. While that particular nucleus is out of reach with this technique, a measurement of the g-factor of ^{76}Kr will add to the even-Kr isotope systematics [2] which provide a sensitive probe of the nuclear wavefunction and competition between single-particle and collective motion.

It happens that the Kr-Br region of the periodic table is not only interesting scientifically, but Kr and Br are easy to work with, because their volatility makes it unnecessary to resort to chemical techniques to separate them from the target. We plan to have do experiments with ^{76}Kr this year, and ^{77}Br and ^{79}Kr beams in the next year.

A thin target of separated ^{74}Se has been developed and used in the reaction ^{74}Se(α, 2n)^{76}Kr at 46 MeV. The 8 mil target is covered by a 5 mil Al cover foil and backed by a water-cooled block. The target is deliberately made thin enough to cover the energy peak of the (α,2n) reaction while minimizing the other reaction channels which will contribute unwanted radioactivity. Since we are using the Upgraded Advanced Electron Cyclotron Resonance (AECR-U) ion source, which is a workhorse of the facility, it is crucial to eliminate any reaction channels which decay into long-lived products (such as ^{73}Se or ^{75}As) which could potentially contaminate the source and make it difficult to maintain.

For safety, the target is double-contained in a box cooled with nitrogen gas. During the irradiation, a closed system is maintained. After the irradiation, the target is allowed to cool for a few hours to let the 1.2 hour isotope ^{77}Kr decay away, then it is heated to the melting point of the Se and He gas is flowed through to collect the volatile products. The Br is trapped out first in a dry-ice trap and the Kr in a LN_2 trap. Initial tests have shown that the two traps do a good job of separating out the two products. The Kr trap will basically be the BEARS trapping set up and the interface to the AECR-U source will be the same.

Tests so far are consistent with calculations, which show we should be able to provide 0.1 nA of ^{76}Kr to an experiment for 8 hours following a 24 hour irradiation at full beam intensity.

Footnotes and References

[†] LBNL

[‡]LLNL

[§]Rutgers University

**DOE ERULF Summer Student (presently at Tuskogee Univ.)

[††]DOE ERULF Summer Student (presently at UCSD)

1 R.D. Hoffman et al., Ap.J. 460 478 (1996)

2 T.J. Mertzimekis, et al, PRC 64, 024314 (2001)